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ABSTRACT

Presented, in abridged form, are recommendations found in "An Agenda for Action," for special note by seconiary school administrators as they carry out their responsibilities for curriculum development and coordination. It is felt that school administrators and curriculum supervisors often have neither the time nor the opportunity to study and evaluate carefully the major proposals advanced for the improvement of instruction in all areas for which they are responsible. This presentation is designed to meet this problem with "An Agenda," by summarizing that paper in eight pages. "Agenda" was the product of a special National Council of Teachers of Mathematics (NCTM) committee, called by the council to develop a detailed position paper to present recommendations for school mathematics in the '80s. (MP)

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MATHEMATICS IN THE 1980s

Recommendations by the Mathematics Community

Old Math, New Math. Now What?

The furor created by the appearance of "new math" on the curriculum scene 20 years ago has largely subsided, though its value and consequences are still debated. Meanwhile, signs indicate a drift back to the substance and classroom patterns of yesteryear, a drift encouraged by widespread appeals to return to the basics, vague and unreasoned as those appeals often are. Comforting as a return to "old math" may be for many parents, some students, and a few teachers of mathematics, every observant layman and all thoughtful teachers know that more practice with long-division problems or six-place trig tables can make only a trivial contribution to the quantitative literacy necessary to live and work productively in the 1980s and beyond.

Leaders in the school mathematics field for several years have sensed the need for a careful updating of the role of their field in the curriculum, and in the last years of the 1970s the National Council of Teachers of Mathematics, alarmed by the direction mathematics education seemed to be taking, set about developing a detailed position paper to contain recommendations for school mathematics for the decade ahead. That paper, An Agenda for Action, was published in the spring of 1980.

Its recommendations were drafted by a special NCTM committee, but An Agenda is much more than just another committee report. It draws on numerous studies, prominent among which was an extensive survey of a number of populations "to collect information on current beliefs and reactions to possible mathematics curriculum changes during the 1980s." That survey was conducted by the Priorities in School Mathematics Project (PRISM), with funding by the National Science Foundation. The 32-page summary of the Prism Project, Priorities in School Mathematics, has just been released.

An Agenda did get media attention when it first appeared, and Priorities probably will also be noted in the press. But school administrators and curriculum supervisors often have neither the time nor the opportunity to study and evaluate carefully the major proposals advanced for the improvement of instruction in all areas for which they are responsible. Because of the importance of providing mathematics programs aligned to the realities of today's world, it was decided to use this issue of CR to present in abridged form those Agenda recommendations worth special note by secondary school administrators as they carry out their responsibilities for curriculum development and coordination.

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Recommendation 1:* PROBLEM SOLVING MUST BE THE FOCUS OF SCHOOL MATHEMATICS IN THE 1980s.

Performance in problem solving will measure the effectiveness of our personal and national possession of mathematical competence. Problem solving encompasses a multitude of routine and commonplace as well as nonroutine functions considered to be essential to the day-to-day living of every citizen. But it must also prepare individuals to deal with the special problems they will face in their individual careers.

True problem-solving power requires a wide repertoire of knowledge, not only of particular skills and concepts but also of the relationships among them and the fundamental principles that unify them. With the need to be able to solve problems in an uncertain future as well as here and now, mathematics needs to be taught as mathematics, not as an adjunct to its fields of application.

Problem solving means applying mathematics to the real world, serving the theory and practice of current and emerging sciences, and resolving issues that extend the frontiers of the mathematical sciences themselves.

The implications for school programs include:

✓ The mathematics curriculum should be organized around problem solving.

- The current organization of the curriculum emphasizes component computational skills apart from their applications. These skills are necessary tools but should not determine the scope and sequence of the curriculum. The need of the student to deal with the personal, professional, and daily experiences of life requires a curriculum that emphasizes the selection and use of these skills in unexpected, unplanned settings.

- Mathematics programs should give students experience in selecting and matching strategies to the situation at hand; which includes learning to formulate key questions, analyze and conceptualize problems, define the problem and the goal, seek out appropriate data, discover patterns and similarities, experiment, transfer skills and strategies to new situations; and being willing to make intelligent guesses.

✓ The definition of problem solving in mathematics should be developed and expanded to include a broad range of strategies, processes, and modes of presentation that cover the full potential of mathematical applications.

- Computational activities in isolation from a context of application should not be labeled "problem solving," and the definition of problem solving should not be limited to conventional "word problems."

- Problem solving, which is essentially a creative activity, cannot be built exclusively on routines, recipes, and formulas.

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*Because only a selection of materials from An Agenda for Action is presented here, the original numbering of items has not been retained except for the major recommendations themselves.

- The student should be confronted with problem situations in numerous other forms besides the traditional verbal format; e.g., presentation through activities, graphic models, observation of phenomena, schematic diagrams, and interaction with computer programs.

- Applications of mathematics to other disciplines such as the social sciences, business, engineering, and the natural sciences should be presented.

Recommendation 2: THE CONCEPT OF BASIC SKILLS IN MATHEMATICS MUST ENCOMPASS MORE THAN COMPUTATIONAL FACILITY.

The full scope of what is basic must include those things that are essential to meaningful and productive citizenship, both immediate and future. Some groups limit basic skills to routine computation at the expense of understanding, applications, and problem solving.

Dangerous, too, is the assumption that skills from one era will suffice for another. Skills are tools. Their importance rests in the needs of the times. Skills once considered essential become obsolete. Time and space for including new skills that are becoming essential must be purchased by eliminating the obsolete.

Professional knowledge of future trends; industrial, financial, engineering, and scientific need; and the demands of daily life are all better arbiters of what is currently essential and what has become obsolete than is our nostalgia as parents or teachers. Specifically:

✓ Changes in the priorities and emphases in the instructional program should be made in order to reflect the expanded concept of basic skills.

- There should be increased emphasis on such activities as: collecting, organizing, presenting, and interpreting data; estimating measures, and mentally estimating results of calculations; and using technological aids to calculate.

- There should be decreased emphasis on such activities as: mastering highly specialized vocabulary not useful later either in mathematics or in daily living; converting measures given in one system to corresponding measures in another system; and working with tables whose usefulness as aids to calculation has been supplanted by calculators and other technological aids (e.g., numerical computations with logarithms).

✓ Estimation activities should be incorporated into all areas of the mathematics program on a regular and sustaining basis, in particular encouraging the use of estimating skills to pose and select alternatives and to assess what a reasonable answer may be.

✓ Teachers should provide ample opportunity for students to learn communication skills in mathematics, and they should systematically guide students to read mathematics and to talk about it with clarity.

✓ The higher-order mental processes of logical reasoning, information processing, and decision making should be considered basic to the application of mathematics.

Recommendation 3: MATHEMATICS PROGRAMS MUST TAKE FULL ADVANTAGE OF THE POWER OF CALCULATORS AND COMPUTERS AT ALL GRADE LEVELS.

Most students must obtain a working knowledge of calculators and computers, including the ways in which one communicates with each and commands their services in problem solving, this in addition to an acquaintance with the role of computers and calculators in current society.

With the increasing availability of microcomputers at decreasing costs, it is imperative that schools play an active part in preparing students to live in a world in which more and more functions are being performed by computers. Specifically:

- ✓ All students should have access to calculators and increasingly to computers throughout their school mathematics program.
- ✓ The use of electronic tools such as calculators and computers should be integrated into the core mathematics curriculum.
- ✓ A computer literacy course, familiarizing the student with the role and impact of the computer, should be part of the general education of every student.
- ✓ All mathematics teachers should acquire computer literacy in order to keep pace with the inevitable sophistication their students will achieve.
- ✓ Secondary school computer courses should be designed to provide the necessary background for advanced work in computer science.
- ✓ Provisions should be made by educational institutions and other agencies to help in the necessary task of educating society's adults in computer literacy and programming.
- ✓ Teachers of school subjects other than mathematics but in which mathematics is applied should make appropriate use of calculators and computers in their instructional programs.

Recommendation 4: STRINGENT STANDARDS OF BOTH EFFECTIVENESS AND EFFICIENCY MUST BE APPLIED TO THE TEACHING OF MATHEMATICS.

Instructional time is a precious commodity; it must be spent wisely. Teachers must apportion instructional time according to the importance of the topic, recognizing that the value of a skill or knowledge is subject to change over time.

Modern technology and educational theory and research have made accessible to today's teachers approaches, materials, and strategies that were not previously available, and teachers at all levels must learn to use this enriched variety of resources.

- ✓ The major emphasis on problem solving in the curriculum must be accommodated by reprogramming the use of time in the classroom.
- ✓ School budgets should provide for a range of instructional resources adequate to support a wide variety of teaching strategies.

Recommendation 5: THE SUCCESS OF MATHEMATICS PROGRAMS AND STUDENT LEARNING MUST BE EVALUATED BY A WIDER RANGE OF MEASURES THAN CONVENTIONAL TESTING.

Evaluation is a part of mathematics teaching, and hence mathematics educators should be centrally involved in the evaluation process. Evaluation includes gathering data and interpreting data. Testing is one source of data, but evaluation should not be limited to testing.

Today, many people use test scores as the sole index of the quality of mathematics programs or of the success of student achievement, but test scores should not be considered synonymous with achievement or program quality. There seems to be an increasing tendency on the part of the public to assume that the sole objective of schooling is a high test score, without regard for what is being tested or for whether test items fit desired goals.

It is imperative that the goals of the mathematics program dictate the nature of the evaluation needed to judge program effectiveness, student learning, teacher performance, and the quality of materials. Too often the reverse is true: tests dictate the programs, or assumptions of the evaluation plan are inconsistent with the program's professed goals.

The evaluation of problem-solving performance will demand new approaches to measuring. Certainly, present tests are not adequate. In particular, the measuring of the use of problem-solving processes will demand innovative techniques.

✓ The evaluation of mathematics learning should cover the full range of the program's goals, including skills, problem solving, and problem-solving processes.

- Minimum competencies should not be construed as an adequate measure of an individual's mathematics achievement. What is minimal for all is optimal for none.
- Nontest evaluation methods and strategies should be discussed with parents, students, and the general public.
- The informed judgment of teachers should be considered a vital part of the evaluation of any student.

✓ The evaluation of materials for mathematics teaching should be an essential aspect of program planning.

✓ The evaluation of mathematics programs should be based on the program's goals, using evaluation strategies consistent with these goals.

- The results of a test designed for purposes other than program evaluation (such as SAT) should not be interpreted as evaluation of mathematics programs.
- Longitudinal evaluation of individual problem-solving ability should be developed. The acquisition of problem-solving skills is a long-term process and should not be evaluated solely with short-term measures.
- Where minimum competency tests are mandated, they should be implemented with extreme caution to assure that adverse effects on the program do not result.

Recommendation 6: MORE MATHEMATICS STUDY MUST BE REQUIRED FOR ALL STUDENTS AND A FLEXIBLE CURRICULUM WITH A GREATER RANGE OF OPTIONS SHOULD BE DESIGNED TO ACCOMMODATE THE DIVERSE NEEDS OF THE STUDENT POPULATION.

The amount of time the majority of students spend on the study of mathematics in school in no way matches the importance of mathematical understanding to their lives, now and in the future. Polls show that the public recognizes mathematics is an essential subject for all students, yet it is typical to find that only one year of mathematics is required for students in grades 9-12.

To say that most students should study more mathematics does not mean simply keeping all students longer in the same traditional track. Such a recommendation, in fact, poses a challenge to curriculum developers to devise a more flexible range of options, a diversified program to meet a variety of interests, abilities, and goals. Except for a distinction among courses typically taken in the ninth grade, differentiation in students' mathematics programs has been based mainly on whether or not a student takes elective years of mathematics.

The growing diversity of applications of mathematics in an increasing variety of college programs demands more than a single college-preparatory program. At the college level, the trend is to broaden the conception of mathematical study to include what are called "the mathematical sciences." Roughly, this means not only mathematics but the delivery of mathematical ideas and tools to the solution of real-life problems. Present high school programs do not fully anticipate the many options provided by mathematics, the mathematical sciences, and computer science.

Technical and vocational training at different levels also assumes more and diverse mathematical backgrounds. For those whose formal education will end with high school, the needs of citizen and consumer for increasing mathematical sophistication dictate a collection of courses based on consumer and career needs, computer literacy, and quantitative literacy.

Curriculum developers should redesign the sequence of the curriculum to realize the critical process goals of problem solving, as well as content and skill goals. A clear and logical developmental sequence for process objectives should be described and serve as an organizing framework throughout the school years.

The goal is to develop a more flexible, deeper, and broader problem-solving power, and this goes significantly beyond the formulas and recipes that have been traditionally applied to familiar problems.

At the same time, the important interplay and integration of mathematics and its applications in learning should not cease because isolated course structure separates mathematics from disciplines that apply it. The principles of learning must take priority over administrative convenience, and it is likely that this coordination will have to be accomplished by voluntary cooperative efforts by teachers of mathematics and other subjects that apply mathematics.

✓ In secondary school, the curriculum should become more flexible, permitting a greater number of options for a diversified student population.

- At least three years of mathematics should be required in grades 9-12. But increasing high school requirements should not result in keeping all students in the same traditional tracks. The recommendations made

herein cannot be met with just the two-track alternatives of either general mathematics courses or precalculus courses typical of many existing programs.

- Algebra should be included in the program of all capable students. But for many students, algebra should be delayed until a level of maturity and basic mathematical understanding permit their taking full advantage of a significant algebra course.

- A course providing progress beyond junior high school but paving the way for a useful experience in consumer mathematics and later algebra needs to be developed.

- Consumer mathematics should develop a broader quantitative literacy and should consist primarily of work in informal statistics, such as organizing and interpreting quantitative information.

- All high school students should have work in computer literacy and the hands-on use of computers, along with the applications of computers where possible and appropriate throughout their mathematics programs.

✔ Mathematics educators and college mathematicians should reevaluate the role of calculus in the differentiated mathematics programs.

- Emerging programs that prepare users of mathematics in nontraditional areas of application may no longer demand the centrality of calculus that has traditionally been demanded for all students.

- In this light, colleges and high schools should reexamine the concept of advanced placement in mathematics. For some students, an advanced placement program restricted to calculus placement may not be the optimal alternative. Advanced placement should be a broader concept that includes options in other branches of the mathematical sciences.

✔ The curriculum that stresses problem solving must pay special heed to the developmental sequence best suited to achieving process goals, not just content goals.

- Since there are usually multiple approaches to all but the most trivial problems, not all students should be expected to proceed in the same way. Value should be placed on a thoughtful and productive approach, not solely on a single correct answer.

- At middle and junior high school levels,

  --the focus of the curriculum should be on more formal and more general problem-solving approaches and strategies;

  --instruction should stress the ability to apply techniques used in one situation to new and unfamiliar situations;

  --instruction should stress the ability to select from a range of strategies and to create new ones by combining known techniques.

- Teachers of mathematics and teachers of other disciplines should cooperate in assuring that students perceive the relationship of the mathematics they learn in mathematics courses to the mathematics applied in problems in other disciplines.

✔ Special programs stressing problem-solving skills should be devised for special categories of students.

- Professionals in mathematics and special education should work together to identify possible and optimal process abilities for students with handicaps and learning difficulties.

- Increased attention should be paid to developing the potential of the gifted student of mathematics; in particular,

  --programs for the gifted should be based on a sequential pattern of enrichment through more ingenious problem-solving opportunities rather than through acceleration alone;

  --materials and resources of a sophistication and depth suitable to the unusual potential of the gifted student in problem solving should be developed.

An Agenda for Action: Recommendations for School Mathematics of the 1980s, and the Executive Summary of the PRISM Project, Priorities in School Mathematics, are publications of the National Council of Teachers of Mathematics, 1906 Association Dr., Reston, Va. 22091.

KUDOS.....Selecting materials from An Agenda for Action for this issue of CR was done by Professor SHIRLEY A. HILL of the University of Missouri--Kansas City and the immediate past president of the National Council of Teachers of Mathematics. It was during her years as president-elect and then president of NCTM that the recommendations in An Agenda were developed.

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